Sandia National Laboratories

Fact Sheet

Batch Supercritical Water Oxidation (SCWO)

Traditional Disposal Options Limited

The alternatives for safe disposal of problematic organic wastes from chemical, medical, biological, military, and nuclear applications are becoming very limited. Traditional disposal options, like deep well injection and incineration, can be extremely costly or unavailable in today's regulated environment. Transportation of wastes to central waste facilities is often against safety regulations or the subject of public resistance.

A technology recently developed at Sandia National Laboratories addresses these problems. Sandia has designed and built a Batch Supercritical Water Oxidation (Batch SCWO) reactor that provides a unique mobile solution for destruction of toxic organic materials.

Portable and Scalable

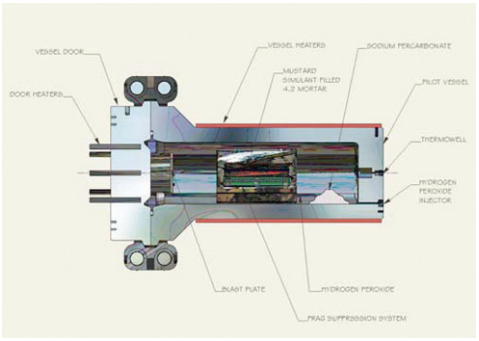
The Batch SCWO unit's unique design minimizes reactor volume, making it small and portable, so materials can be destroyed where they reside. Portability eliminates the risk and expense involved in transporting waste to central facilities. The design is scalable, allowing units to be right-sized for different applications or scenarios. It is an ideal system for low capacity, campaign-style destruction of organic materials.

Based on SCWO

Stack emissions from incineration, the most prevalent means of waste destruction around the world, pose serious environmental and health concerns.

The Batch SCWO system is based directly on supercritical water oxidation, a process first invented in 1979 that completely converts organic materials to carbon dioxide, water, and inorganic acids at conditions above the critical point of water. Unlike incineration, SCWO operates at relatively mild temperatures (400º- 650ºC), where metal alloys maintain their mechanical strength. SCWO overcomes the control difficulties inherent in flame processes by strictly regulating the temperature and residence time required for waste destruction.

SCWO is a demonstrated waste destruction technology that has been applied to continuous and isothermal flow reactors. To date, applications have been limited to pumpable, homogenous liquid waste streams in large volumes. The weaknesses of flow systems (immobility, complex to monitor and operate, and suited only for well characterized pumpable waste) are overcome by the Batch SCWO reactor.



Complete Organic Destruction

The batch nature of Batch SWCO makes it ideally suited to process a wide variety of wastes and waste forms, including solids, fabrics/PPE, and slurries.

Conceptually illustrated below, the Batch SCWO reactor provides the high destruction efficiency of supercritical water oxidation in a compact and mobile package. The reactor is loaded with the waste. A peroxide solution (oxidizer) is injected into the vessel. A base or buffer solution can be added to neutralize the acid, thereby reducing corrosion of the reactor vessel. The vessel is sealed and leak tested and then the shaped charges, if used, are detonated to expose the chemical agent and explosive. The vessel is then heated until the temperature reaches approximately 550°- 600°C. If shaped charges are not used to expose the chemical agent, auto-ignition of the munition burster or internal pressure caused by heating of the fluids in the munition or CAIS vial causes the munition, burster housing, or vial to break open thereby exposing the contents to the hydrogen peroxide. Typical operating pressure is 4,000 psi. At this condition, the chemical agents and unoxidized explosive residue are completely oxidized, producing carbon dioxide, water, nitrogen, and inorganic salts. Once the oxidation reaction is complete, the vessel is cooled, drained, and prepared for the next

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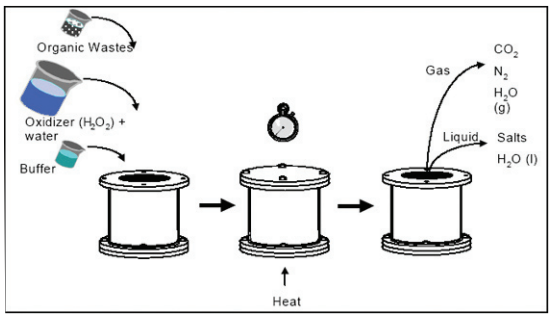
operation. A sample of the effluent can be removed from the vessel for chemical analysis to confirm destruction of the CWM prior to draining the vessel. The reactor vessel is designed to contain both the detonation and the high pressure and temperature.



Operating conceptually like a pressure cooker, a batch reactor can resolve all of the issues associated with larger, more complex systems. For instance:

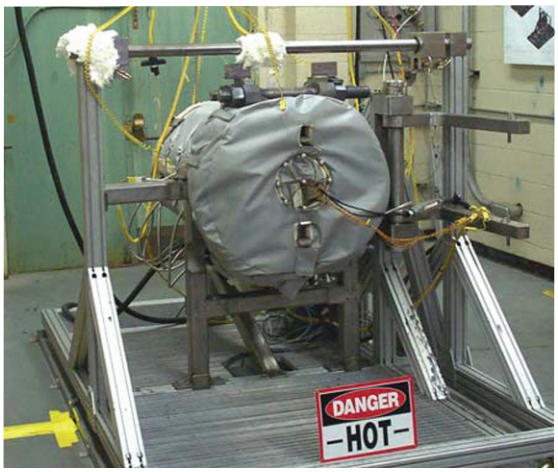
- There are no limitations on residence time.
- Since it is not a steady-state system, the heating value of the waste can vary.
- It can handle gas, liquid, or solid wastes.
- The design is simple with no high-pressure pumps or pressure let-down valves.
- Unlike steady-state systems, there are no start-up or shut-down issues.
- Corrosion and salt deposition, major challenges in SCWO flow reactors, are minor issues because the process does not involve flow.
- No fugitive emissions – the processed waste and resulting byproducts are completely contained.

Bench-Scale Testing

Several 0.3 liter prototype Batch SCWO reactors have been manufactured for testing at Sandia. The bench-scale reactors are used to demonstrate destruction efficiencies, optimize testing parameters, and to do a Materials of Construction study. The destruction tests show that the Batch SCWO process consistently destroys surrogate neutralent from either GB (nerve agent) or H (mustard agent) to less than 25 ppm of total organic carbon using hydrogen peroxide as an oxidizer at reaction conditions of about 600°C and 4,200 psi. Testing was also successfully completed on CAIS vials (glass ampoules that contain small quantities of chemical warfare materiel) to demonstrate accessing and destruction of the vial contents. The bench-scale reactors are currently being used to perform a Materials of Construction study to evaluate the various corrosion and stress corrosion cracking properties of various materials when exposed to the Batch-SCWO environment.

Pilot System

A 34-liter Batch SCWO sub-scale pilot vessel designed for the destruction of explosively configured chemical weapons and CAIS vials has been built and has completed baseline testing. Explosive qualification tests have been performed on the pilot system. These tests adequately demonstrated the explosive capacity of the vessel. Baseline testing demonstrated the process efficacy of the system.



Pilot scale unit

Commercial Applications

Batch SCWO promises to be effective in treating a wide range of government and industrial wastes, making it a promising candidate for further development and commercialization. Possible applications include treatment of:

- Shipboard excess hazardous materials
- Corrosive waste streams
- Chemical agents, including warfare agents like nerve and mustard gases
- Energetic materials, like solid rocket propellants
- Biomass and human wastes, perhaps in space
- Waste treatment and resource recovery

Advantages of the Batch SCWO system include high destruction efficiencies, relatively low temperature operation, mobility, simplified permitting, compact size, and competitive cost.

Learn more at
http://www.sandia.gov

For more information contact
Sandia National Laboratories
Mary Clare Stoddard at (925) 294-2056
mcstodd@sandia.gov